

China Lake Quadrangle, Maine

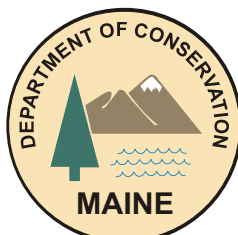
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SURFICIAL GEOLOGY OF MAINE

Continental glaciers like the ice sheet now covering Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 1.5 million and 10,000 years ago. The slow-moving ice superficially changed the landscape as it scraped over mountains and valleys (**Figure 1**), eroding and transporting boulders and other rock debris for miles (**Figure 2**). The sediments that cover much of Maine are largely the product of glaciation. Glacial ice deposited some of these materials, while others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted, creating hundreds of ponds and lakes across the state. The map at left shows the pattern of glacial sediments in the China Lake quadrangle.

The most recent "Ice Age" in Maine began about 25,000 years ago, when an ice sheet spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier actually caused the land surface to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed. The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock, and they are important indicators of the direction of ice movement (**Figure 3**). Erosion and sediment deposition by the ice sheet combined to give a streamlined shape to many hills, with their long dimension parallel to the direction of ice flow. Some of these hills (drumlins) are composed of dense glacial sediment (till) plastered under great pressure beneath the ice.

A warming climate forced the ice sheet to start receding as early as 21,000 years ago, soon after it reached its southernmost position on Long Island (Sirkin, 1986). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by 13,800 years ago (Dorion, 1993). Even though the weight of the ice was removed from the land surface, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated to the northwest. Ocean waters extended far up the Kennebec and Penobscot valleys, reaching present elevations of up to 420 feet in the central part of the state.

Great quantities of sediment washed out of the melting ice and into the sea, which was in contact with the receding glacier margin. Sand and gravel accumulated as deltas (**Figure 4**) and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor. The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine. Age dates on these fossils tell us that ocean waters covered parts of Maine until about 11,000

years ago, when the land surface rebounded as the weight of the ice sheet was removed.

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared (**Figure 5**). Maine's esker systems can be traced for up to 100 miles, and are among the longest in the country.

Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier. Many of these water-laid deposits are well layered, in contrast to the chaotic mixture of boulders and sediment of all sizes (till) that was released from dirty ice without subsequent reworking. Ridges consisting of till or washed sediments (moraines) were constructed along the ice margin in places where the glacier was still actively flowing and conveying rock debris to its terminus. Moraine ridges are abundant in the zone of former marine submergence, where they are useful indicators of the pattern of ice retreat (**Figure 6**).

The last remnants of glacial ice probably were gone from Maine by 10,000 years ago. Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys (**Figure 7**). The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today, however, since rivers and wave action modify the land (**Figure 8**), and worldwide sea level is gradually rising against Maine's coast.

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Figure 1: Ablation till over basal melt-out till on the northern part of Spruce Mountain, Franklin County, Maine. The lower, more uniform melt-out till unit was deposited directly by glacier ice and is quite typical of glacial till. The upper cobble- and boulder-rich sediment melted out on top of the glacier and was sorted by water and gravity processes. This is very similar to till on the China Lake quadrangle.



Figure 2: Boulder to pebble gravel (right side) deposited in the ice tunnel leading to the Erskine Academy delta, southern China Lake quadrangle. This esker sediment is overlain by more fine-grained glaciomarine sediment (upper left side) that contains coarse material that slumped off the esker during recession of the ice sheet.



Figure 3: Sandy gravel foreset beds in the Erskine Academy delta, southern China Lake quadrangle. Water discharged from the ice sheet margin to the right, and the delta built outward toward the left into the ocean.



Figure 4: Sandy, more distal sediment of the glaciomarine Meadow Brook delta. Two normal faults (left of the shovel) outline a block of sediment that settled downward. The folded beds above the faults might represent deformation caused by water expulsion as the fault block settled.



Figure 5: Ice-contact pebble to boulder gravel deposited in proximal part of glaciomarine fan environment. Sediment collapsed as ice melted.



Figure 6: Gray Presumpscot Formation overlain by high-energy sandy gravel. The sandy gravel either marks a shift in location of the water-discharge point from the former ice margin or redeposition from wave and current action as relative sea level fell.



Figure 7: Fossiliferous glaciomarine silt and clay of the Presumpscot Formation (Palermo 7.5-minute quadrangle, located just northeast of the village of China). Sediment deposited in low-energy glaciomarine environment in arctic, ice-proximal conditions.



Figure 8: Fossil shells in silt, clay, and sand of the Presumpscot Formation. Sediment deposited in low-energy glaciomarine environment in arctic, ice-proximal conditions. Shells at this site (Palermo 7.5-minute quadrangle, located just northeast of the village of China), were radiocarbon dated to 11,380±230 C-14 yrs ago (corrected with -600-yr reservoir correction factor).